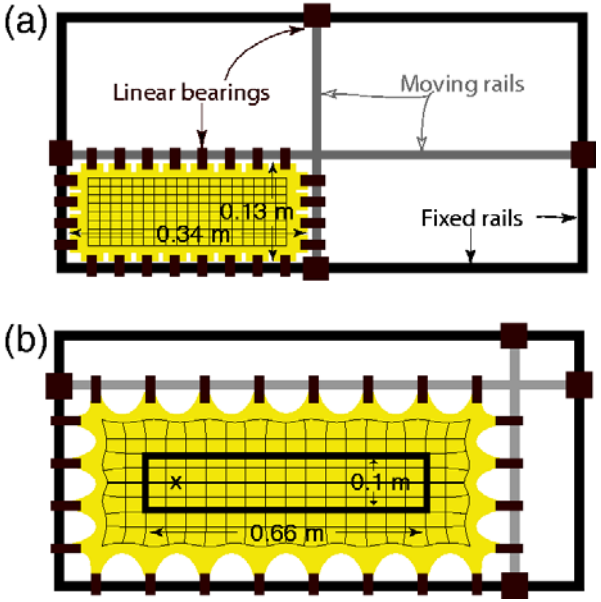
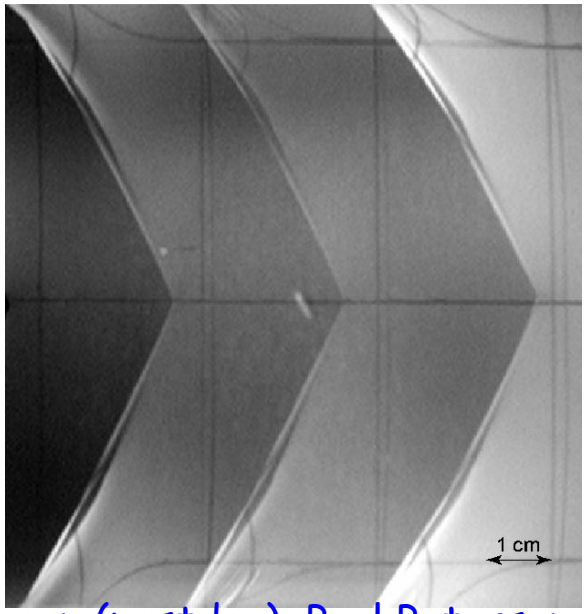
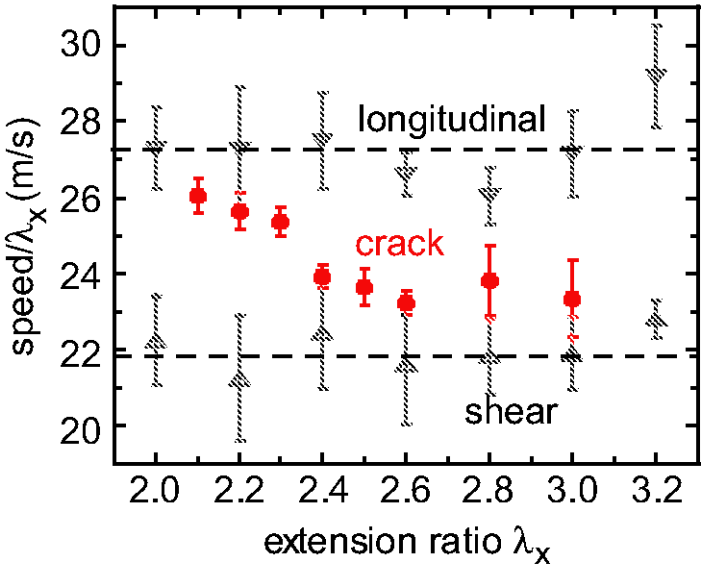
A new type of failure

- Polymer films ubiquitous.
- Travelling ruptures in rupture look different from traditional cracks; but are they really shock waves?
- Answer: yes. They are supersonic, and the rupture edges are Mach cones.
- First experimental demonstration of intersonic failure in tension







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Introduction

Previous dynamic fracture studies have often been concerned with the speed of crack propagation through a material, the branching that occurs when the crack speed approaches the sound speed in the material, and the path that a crack will take in a material under varying strains. The existing theory cannot predict these quantities for crack paths, but we believe that our studies of oscillating crack paths will provide a fresh perspective, perhaps providing details to complete the theory.

Summary of results

We have studied crack paths in latex rubber sheets stretched in two orthogonal directions, and observed that originally straight cracks undergo a transition to oscillating paths as the amount of biaxial strain is increased. We mapped a phase diagram of these states, and from measurements of the amplitude and wavelength of the oscillation near the onset of the instability, find that this transition can be characterized as a Hopf bifurcation. Finally, we ruled out several possible mechanisms that could drive this instability.

Phase Diagram

The resulting paths for many runs are plotted as a function of strain. A boundary is drawn between straight cracks (open circles) and oscillating cracks (filled circles) to guide the eye. The limits at the top of the diagram exist because large strains in the sheet induce spontaneously running cracks, making it difficult to collect data for $e > 2.6$. As the y-strain becomes small ($e < 1.4$) and approaches the x-strain, the wavelength of the oscillation becomes large (inset figure), causing difficulties in distinguishing straight cracks from long wavelength oscillating cracks.

New Apparatus

A stretching apparatus currently being built will eliminate the amount of time required for each run, and will allow for a greater rate of data collection. The apparatus is designed with linear bearings riding on guide rails. An outer frame of these rails will support two perpendicular mobile rails. Riding on these rails, a collection of linear bearings with clamps will hold the sheet, and the moving rails will be extended, stretching the sheet. The result will be much more rapid data collection, enabling us to settle some remaining questions before proceeding to a long publication.

NSF-Funded Fracture Experiments help educate preservice teachers.

All students in UTeach, the preservice program for secondary science, mathematics and computer science at UT Austin take a course on the nature of scientific research in which they design their own experiments. The course begins by illustrating how one can perform original scientific work ...starting with something as simple as careful observation of how things break.

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Phys. Rev. Lett. 87, 010102 (2001), Phys. Rev. Focus: http://focus.aps.org/v9/st1.htm.; Physical Review Letters, 93, 015504 (2004)

Austin 5th graders during science enrichment, summer 2004; cooperative agreement with Austin Independent School District. Student aides for project are UTeach preservice candidates